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EFFECTS OF ILLUMINATION LEVEL AND SENSE OF DIRECTION ON LAND NAVIGATION PERFORMANCE

Joseph I. Peters, Paul R. Bleda, and
Michael L. Fineberg

ENGAGEMENT SIMULATION TECHNICAL AREA

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U. S. Army
Research Institute for the Behavioral and Social Sciences

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The ability of foot soldiers to move at night affords unique military advantages (a) because of the natural cover provided by darkness and (b) because it allows the Army to perform continuous (around the clock) operations. This research quantitatively assessed the ability of infantrymen to perform a navigation task in conditions of limited visibility without the aid of night vision devices. Simulation of night was also tested by having the soldiers wear light-attenuating devices, and individual differences between

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good and poor navigators were studied with regard to the soldier's personal history, attitudes, and performance on cognitive tests aimed at discriminating sense of direction. The experiment required 30 soldiers to perform a dead-reckoning task to four checkpoints over a 2,330 m course in mountainous desert. Ten soldiers navigated during the day, 10 navigated at night, and the remaining 10 navigated in the day but wore light-attenuating devices to simulate night. Half the soldiers in each group had a poor sense of direction, according to their own self-ratings, and the other half a good sense of direction.

The results indicated that although both navigation speed and accuracy were degraded to some degree, only navigation speed was significantly affected by night illumination. Compared to daylight performance, those in the simulated night condition performed like those navigating in actual night. Navigators with a good self-rated sense of direction tended to perform better than those with a poor self-rating. Among the tests and questions correlated with performance, only items relating to navigation experience were significant. Neither cognitive style nor items related to city versus country childhood were predictive of navigation ability.

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EFFECTS OF ILLUMINATION LEVEL AND SENSE OF DIRECTION ON LAND NAVIGATION PERFORMANCE

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Land Navigation

ARI Research Reports and Technical Papers are intended for sponsors of R&D tasks and other research and military agencies. Any findings ready for implementation at the time of publication are presented in the latter part of the Brief. Upon completion of a major phase of the task, formal recommendations for official action normally are conveyed to appropriate military agencies by briefing or Disposition Form.

FOREWORD

The Continuous Combat program of the Army Research Institute for the Behavioral and Social Sciences (ARI) assesses human performance in military operations that take place both day and night and particularly examines performance in land navigation. The purpose of the research is to improve land navigation training with computer and simulation techniques, to determine the behavioral differences in navigation abilities in order to define psychological principles behind good navigation skills, to develop a valid methodology for evaluating navigation performance, and to determine the perceptual, cognitive, and emotional effects of day versus night ability on navigation. The research program is responsive to the requirements of the U.S. Army Forces Command (FORSCOM) and is conducted under Army Project 2Q163743A774, Man-Machine Interface in Integrated Battlefield Control Systems, FY 1977 Work Program. The research reported in this report was directed by Dr. Aaron Hyman, chief of the Human Factors in Tactical Operations Technical Area.

This report explores differences in soldiers' land navigation performance during day, night, and simulated night conditions. Light attenuating devices (LADs) were used for simulating night illumination levels under daylight conditions. Performance differences were also assessed between soldiers who rated themselves as having a good sense of direction versus those who rated themselves as having a poor sense of direction.

Supporting the research efforts were the 9th Infantry Division at Fort Lewis, Wash., which was the FORSCOM sponsor; and LTC D. Van Eynde, commander of the 2d Battalion, 39th Infantry. Mr. D. Dressel of ARI helped to plan and design the experiment.

JOSEPH ZEIDNER
Technical Director

ILLUMINATION LEVEL, SENSE OF DIRECTION, AND LAND NAVIGATION PERFORMANCE

BRIEF

Requirement:

The ability of foot soldiers to move at night provides the military advantages of natural cover provided by darkness and potentially continuous (around the clock) operations. This research assessed quantitatively the ability of infantrymen to navigate under conditions of limited visibility without the aid of night vision devices.

Simulation of nighttime conditions during the day would simplify observation of soldiers' night navigation performance. Simulation of night by having some soldiers wear light-attenuating devices (LADs) was tested.

Individual differences between good and poor navigators have implications for training as well as selection. Such differences were studied with regard to the soldier's personal history, attitudes, and performance on cognitive tests aimed at discriminating sense of direction.

Procedure:

Thirty soldiers performed a dead-reckoning task to four checkpoints over a 2,330 m course in mountainous desert. Ten soldiers navigated during the day, 10 navigated at night, and the remaining 10 navigated in the day while wearing light-attenuating devices to simulate night. Half of the soldiers in each group were designated, according to their own self-ratings, as having a poor sense of direction; the other half designated themselves as having a good sense of direction. Soldiers' performance was evaluated on the basis of navigation speed and distance error in locating checkpoints. Navigation performance was correlated with the number of past exercises in navigation as well as scores from standardized tests of intelligence and cognitive style.

Findings:

Although both navigation speed and accuracy were reduced to some degree, only navigation speed was significantly affected by night illumination. Overall, navigation times decreased by 40% at night.

Compared to daylight performance, those in the simulated night condition performed similarly to those navigating at night. That is, the light-attenuating devices significantly reduced navigation speed and, to a lesser degree, increased navigation error. Further testing is required to validate the devices more fully.

Navigators with a good self-rating for sense of direction performed consistently better than those with a poor self-rating. These results were not significant, but indicate the need for more refined research in this area.

Among the tests and questions, only navigation experience correlated significantly with performance. Neither cognitive style nor items related to city versus country childhood were predictive of navigation ability.

Utilization of Findings:

Troops who move tactically by night dead-reckoning can be expected to lose up to 40% of their navigation speed in mountainous desert terrain.

The use of a light-attenuating device to simulate night will degrade navigation performance in the same manner as actual night. Navigation speed is significantly reduced, with less reduction in navigation accuracy. Filters which provide more light at the bottom of the lens will not substitute for night completely but will simulate important aspects of the night environment for training purposes.

Increased practice with navigation problems will increase soldiers' navigation proficiency. Soldiers who rated themselves as having a good sense of direction tended to navigate better than those with a poor sense of direction; such ratings were highly correlated with the number of past navigation experiences.

ILLUMINATION LEVEL, SENSE OF DIRECTION, AND LAND NAVIGATION PERFORMANCE

CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

ILLUMINATION LEVEL, SENSE OF DIRECTION, AND LAND NAVIGATION PERFORMANCE

BACKGROUND

The impetus for studying the land navigation proficiency of combat personnel derives from the evolution of the tactics and doctrine of the modern Army. According to current thinking, future battlefields will not consist of large masses of troops in entrenched positions, but will be characterized by a fluid type of warfare. The outstanding feature of mobile warfare is the multiplication of power by the rapid concentration of forces at a certain point and at a certain time. The related doctrine of continuous combat specifies that tactical operations will be conducted around the clock, under all types of weather conditions, and across various terrains. The evolution of mobile and continuous combat tactics has brought with it an increasing demand for skill in land navigation and map interpretation. These demands were detailed in an article in Infantry[1] that classified the technical proficiency requirements of infantrymen into two broad categories: (1) navigation and map use and (2) weapons proficiency.

This report describes the results of an experiment directed at the study of navigation and map use. The experiment was designed to evaluate factors that affect development of training and selection procedures for increasing night mobility effectiveness of operational troops without the aid of expensive night vision devices.

The major purpose of this experiment was to obtain baseline measures of navigation speed and accuracy as a function of day versus night illumination levels. In addition, because of the increased emphasis on maximizing night movement and the problems related to observing navigation performance at night, the concept of simulated night conditions was tested to provide a potentially useful technique for easily assessing night performance during the day. This simulation of night was produced by equipping soldiers with light-attenuating devices (LADs) developed at ARI.

In addition, individual differences in navigation abilities among soldiers were studied. Although little is known about what makes a good navigator, evidence indicates that people can assess their own

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[1]The Infantry Leader: Tactically and Technically Proficient. Infantry, January-February 1976, vol. 66, no. 1, 20-26.

sense of direction rather well (Kozlowski & Bryant, 1977).[2] To validate this self-assessment technique, soldiers were divided into two groups--good and poor--based upon their assessment of their sense of direction (SOD). Much information could be obtained if, in fact, the good--as self-rated--soldiers navigated significantly faster or more accurately than the poor--as self-rated--soldiers. The source of such differences in performance could be identified more easily, and the underlying psychological principles could be applied to navigation training procedures as well as to selection of expert navigators.

To supplement the self-assessment procedure, a battery of tests and questions was given to determine if demographic or cognitive tests can predict who will be good navigators.

METHODOLOGY

Thirty soldiers were tested on a dead-reckoning navigation task. Ten soldiers navigated during the day, 10 navigated at night, and the remaining 10 navigated during the day under simulated night conditions with the use of the LADs. Before they performed the navigation task, the soldiers were administered a battery of cognitive tests and questions on their backgrounds and attitudes. Based on self-ratings of sense of direction, half of the soldiers in each illumination condition were grouped as having a poor sense of direction, and the other half were classified as having a good sense of direction.

For the navigation task, soldiers were given maps of the area with their routes drawn on the maps. The route, located on the Yakima Firing Center Military Reservation near Yakima, Wash., extended 2,330 m through desert terrain and was divided into four separate legs. The magnetic azimuths and metric distances to each of the four checkpoints were listed for the soldiers on the maps. Each soldier was required to lead the experimenter to each checkpoint.

RESULTS

The major purposes of this experiment were to determine the effects of day versus night illumination levels on soldiers' navigation speed and accuracy and to validate the concept of using LADs to simulate night conditions. A secondary purpose was to determine if a soldier's assessment of his own sense of direction would reflect reliable differences in navigation performance. In addition, the experiment investigated the possibility that demographic background or performance

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[2] Kozlowski, L. T., & Bryant, K. J. Sense of Direction, Spatial Orientation, and Cognitive Maps. Journal of Experimental Psychology: Human Perception and Performance, 1977, vol. 3, no. 4, 590-598.

on selected cognitive tests could predict good navigators. Navigation accuracy was measured as the number of meters between the actual checkpoint and the location of the checkpoint as designated by the soldier. Navigation speed was measured in minutes for each leg of the route. Both the illumination conditions and the self-ratings of sense of direction were evaluated with these error and time measures, and the predictive ability of the tests and demographic variables were assessed through correlational techniques.

Illumination Variables

There was an overall degradation in performance as a result of the nighttime conditions. Although such a degradation was not surprising, the data and field observations of navigation behavior provided interesting insights. For example, although both speed and accuracy diminished at night, the analysis indicated that only navigation speed was degraded by a significant degree. Such results did not support the expectation that darkness would cause more soldiers to "get lost" as would be indicated by significantly poorer performance in both navigation speed and accuracy. As with night illumination, the simulated night conditions produced by the LADs also degraded navigation performance. Such degradation supports the validity of the LADs as a possible research and training tool.

Figure 1 presents the mean navigation times for the Day, LAD, and Night groups in each of the four legs of the route. When measured across the legs, these times reflected significant differences among all groups. As one would predict, the Day group had the fastest times, and the Night group had the slowest times. On the average, navigation time increased 40% under night conditions. A standard of 3,000 m was used as a probable distance required for travel near enemy lines, and a linear relationship was assumed between navigation time and distance. Thus, the data project the daylight travel times would be 47 minutes, compared to 67 minutes at night. This represents a 20-minute difference for a relatively easy dead-reckoning task in open terrain.

The LADs used in the experiment were designed to reduce the ambient light level to that of a partially moonlit evening. Because the LADs had not been tested previously in the field, safety considerations required the use of bidensity filters in the LADs. These filters provided more light at the bottom of the lens so that soldiers could more easily verify their footing; however, these filters prevented seeing distant land cues with equal ease. The data in Figure 1 suggest that even after the novelty effects wore off (represented in Leg 1), the LADs still degraded the soldiers' navigation speed to a significant degree. Apparently, however, the safety feature of the bidensity concept allowed soldiers to travel significantly faster than those traveling in actual night conditions. If the safety feature had not been used, performance times of the LAD and Night groups probably would not have differed.

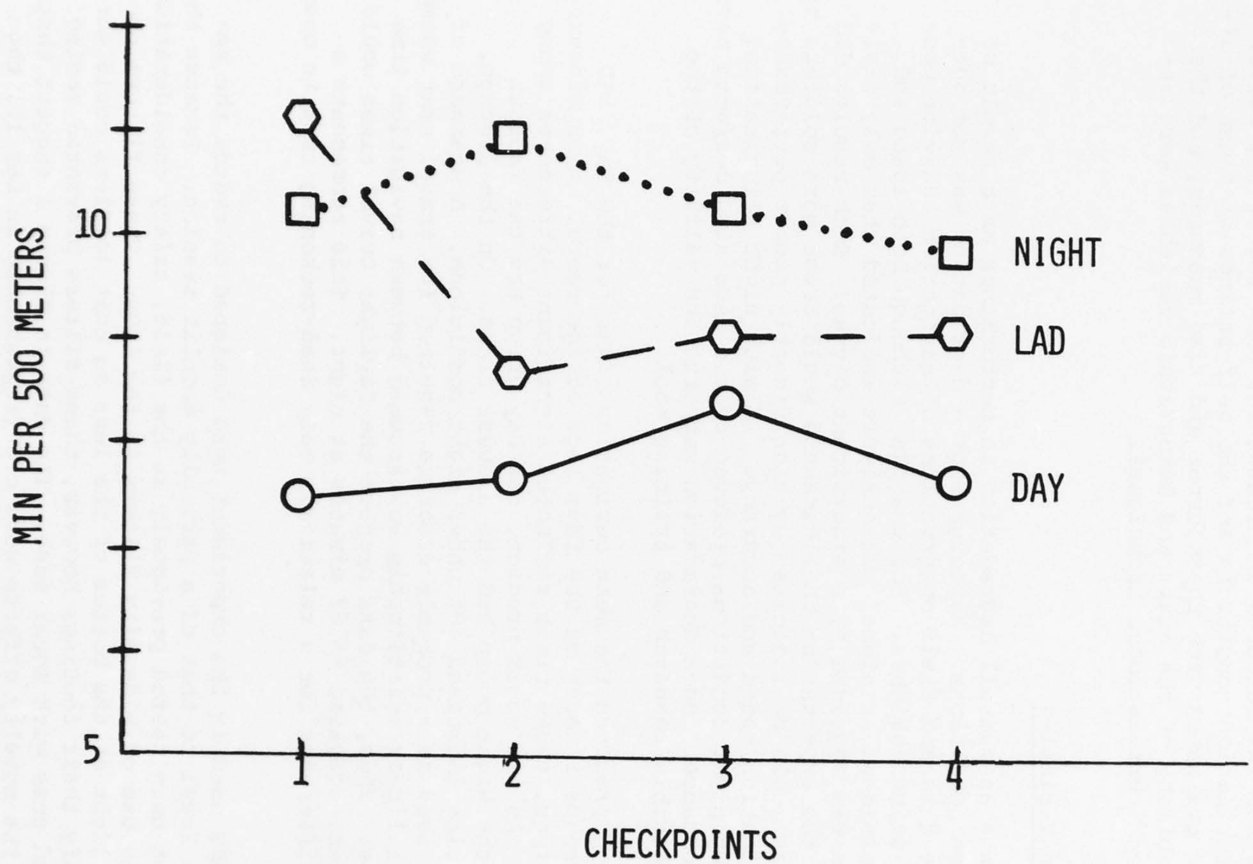


Figure 1. Leg navigation times for three illumination groups.

Figure 2 presents the mean checkpoint distance errors of the three illumination groups for each leg of the route. Those navigating at night had a 60% greater error in locating the checkpoints than did those navigating by day. Performance of the LAD group generally fell between performances of the Day and Night groups. Although the relative performance of the groups was as predicted, the statistical analysis indicated that, unlike navigation times, the average checkpoint errors were not significantly different. The simplicity of the dead-reckoning task combined with the "easy" line-of-sight navigation conditions appear to have made navigation accuracy less of a problem than navigation speed. Had the navigation route been in more difficult terrain with heavy woods that precluded line-of-sight navigation, checkpoint accuracy might have been significantly affected by the illumination conditions.

Sense of Direction

Soldiers who had rated themselves as having a good SOD tended to navigate better than those who rated themselves as having a poor SOD. That is, although there were no statistically significant differences between the groups, good SOD soldiers navigated more quickly and with less checkpoint error than poor SOD soldiers. An increase in the number of soldiers tested might have resulted in group differences with the desired statistical significance.

Figure 3 presents the average navigation times for the two SOD groups over the entire 2,330 m course. In comparing the groups across illumination conditions, one can see little difference between good and poor SOD soldiers in the daylight condition. Under the simulated night condition (LAD) and the actual night condition, the poor SOD soldiers took about 25% and 16% longer, respectively, to navigate than did the good SOD soldiers. Although such differences were not statistically significant, it does appear that something, perhaps the stress induced by night conditions and especially the LAD's simulation of night, reduced the navigation speed of the poor navigators.

Figure 4 shows the average checkpoint distance errors for the two SOD groups. Compared to good SOD soldiers, poor SOD soldiers made consistently greater checkpoint distance errors across all illumination conditions. This was unlike the navigation speed measures in which both good and poor SOD soldiers appeared to do equally well under daylight conditions. Overall, poor SOD soldiers displayed a 15% to 20% greater error than good SOD soldiers. This difference was not statistically significant; however, the consistency across illumination conditions lends support for further research on the validity of self-assessment techniques for selecting navigators.

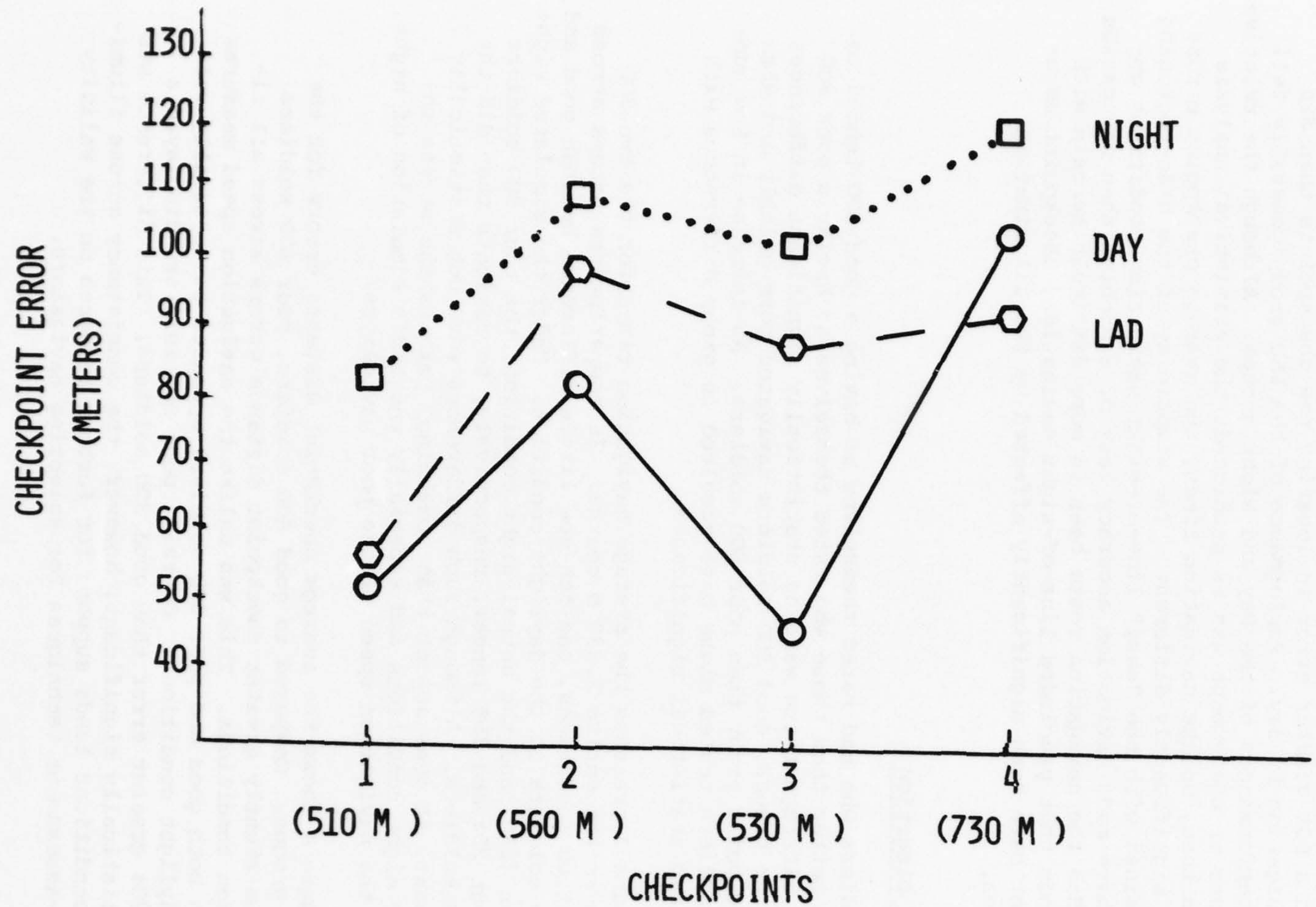


Figure 2. Checkpoint distance errors for three illumination groups.

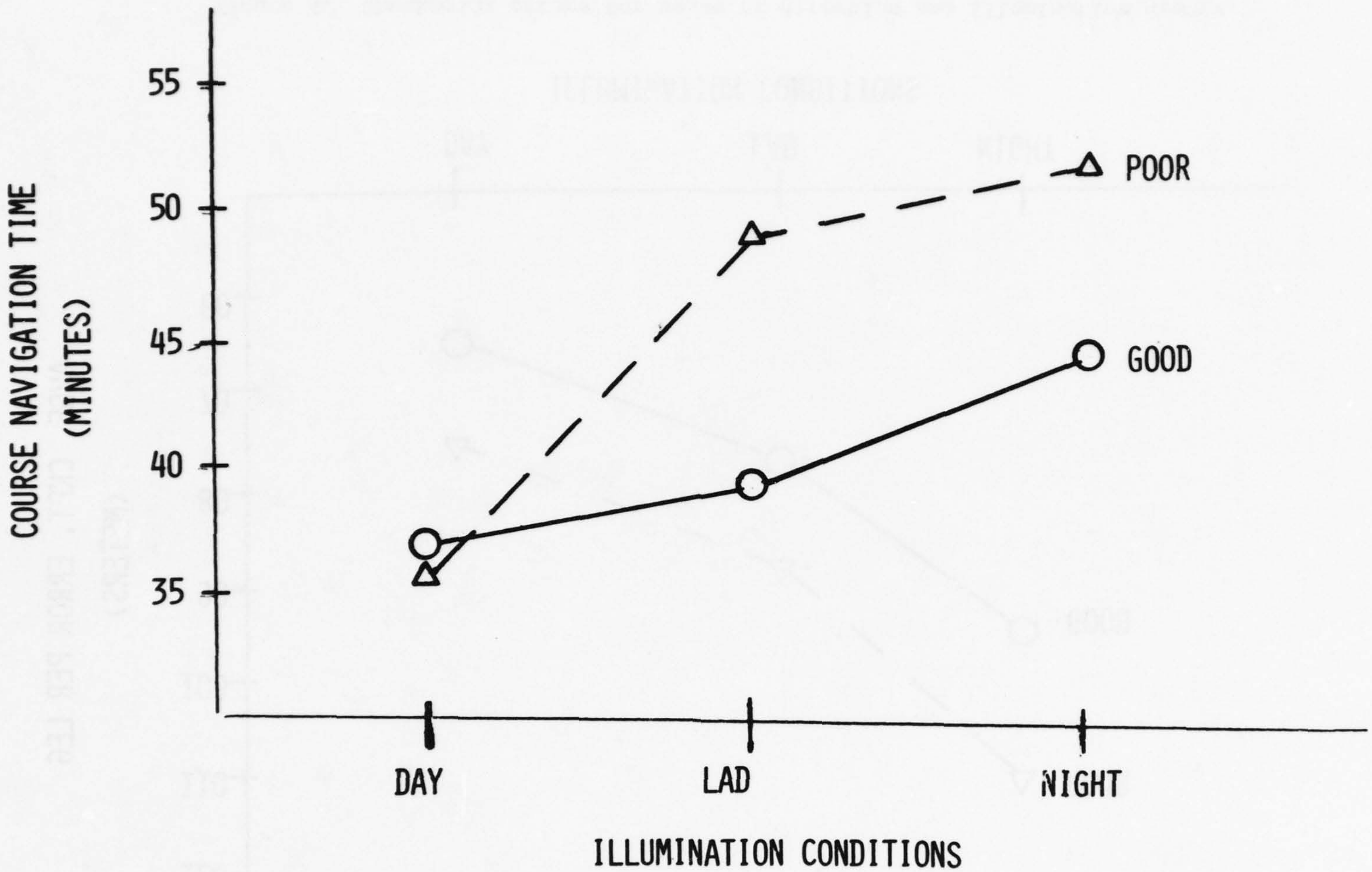


Figure 3. Course navigation times for sense of direction and illumination groups.

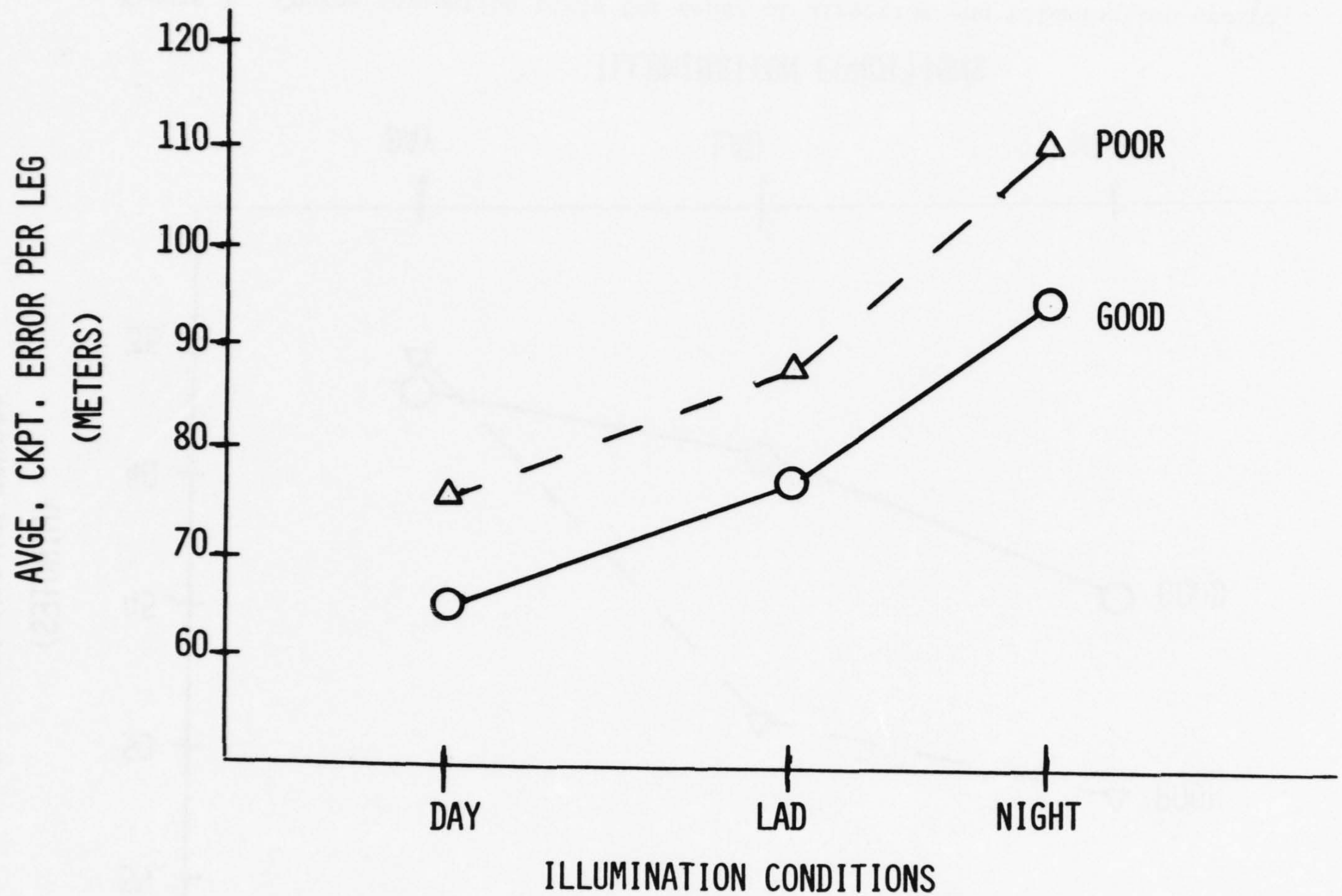


Figure 4. Checkpoint errors for sense of direction and illumination groups.

Prediction of Good Navigators Based on Demographics and Cognitive Tests

The adage that "country boys" are better navigators than "city boys" was tested by correlating demographic data on the soldiers with their navigation performance. In addition to demographics, soldiers' responses to questions such as "How often do you go hiking?", "Do you prefer to be the driver or passenger when riding in a car?", and "Do you like to read maps?" were correlated with actual performance. Also, soldiers' scores on formalized tests such as the Witkin's Embedded Figures Test and the Locations Test under the Armor Systems Selection Battery were correlated with performance.

The results of these correlational analyses indicated that navigation experience displayed the strongest relationship with actual navigation performance. Those who had been in the Army for 2 years or longer and those who had participated in more than seven field exercises in land navigation performed significantly better than soldiers with fewer years of experience or less practice in navigation. There was no evidence, however, that those who had lived in the country performed better than those who had grown up in an urban area.

As discussed above, those who rated themselves as having a good SOD navigated consistently better than those with a poor self-rating of SOD. In a further analysis of this phenomenon, it was found that soldiers with a better sense of direction regarded themselves as people who inspect a map before departing on the auto trip, enjoy map reading, stay calm when they feel they are lost, and are good at remembering verbal directions.

From these results, good navigators appear to be more experienced map users and therefore more able to translate symbolic representations of the terrain into a mental schema to which they can refer while navigating.

The correlations of performance with scores on the formalized cognitive tests were not predictive of good navigators. The low correlation of performance with scores on the AFQT, Locations Test, and Embedded Figures Test indicated that neither intelligence nor perceptual style contributed to good navigation performance. The trend of better performance among better self-rated navigators and the high correlation of such self-assessments with attitudes toward maps contribute to the evidence relating past experience with good navigation performance. It also supports the conclusion that better navigators do not have an innate homing or orientation instinct. In addition, having lived in rural areas does not imply exposure to more navigational experiences, i.e., that "country boys" are better navigators than "city boys." The observed deficiencies in basic skills of compass usage, map reading, and pace counting support a hypothesis that poor navigators have had insufficient experience to develop such skills adequately.

CONCLUSIONS

Given a dead-reckoning task in desert terrain, soldiers' navigation speeds will significantly decrease under nighttime conditions; however, navigation accuracy, although degraded, is not as seriously affected. Navigation performance in a heavily wooded environment was not tested but could compound the task sufficiently that soldiers would indeed get lost.

Simulation of night with LAD can provide an observer with all the advantages of daylight visibility while evaluating the night navigation behavior of soldiers. The validity of the LADs for simulating night was supported by the significantly degraded navigation performance of those who wore the device. Further testing of the LADs is needed.

Soldiers who rated themselves as having a good sense of direction navigated consistently faster and with fewer errors than those who rated themselves as having a poor sense of direction. Although such differences were not statistically significant, the trends in performance suggest that the difficulty associated with more demanding navigation tasks may reveal the utility of self-evaluation for selection and training purposes.

"Country boys" do not navigate better than "city boys." An analysis of the soldiers' backgrounds showed no significant relationship between navigation performance and factors pertaining to childhood environment. With regard to cognitive tests, neither general intelligence (AFQT) nor perceptual style (field dependence vs. independence) correlated highly with navigation performance.

Navigation experience correlated most highly with individual performance. Soldiers who had been in the Army more than 2 years and who had had more than seven exercises involving land navigation demonstrated significantly better navigation performance. These results reinforce the need for training by increasing the exposure of soldiers to actual navigation problems.

TECHNICAL SUPPLEMENT

METHODOLOGY

Subjects

One hundred soldiers were randomly selected from A, B, and C companies of the 2d Battalion, 39th Infantry at Fort Lewis, Wash. From this number, 45 were selected as experimental candidates, of which 30 were tested in the navigation task.

Apparatus

Light-Attenuating Devices (LADs). The LADs used in this experiment consisted of the standard protective field mask (M17A1) to which light-attenuating lenses were added as outserts. The lenses, or filters, reduced the ambient light level to that of a partially moonlit evening. Because these filters had not been tested in the field, a bidensity version of the filters was incorporated into the mask as a safety factor. Such filters provided more light at the bottom of the lens so that users could verify their footing more easily; however, users could not see distant land cues with the same ease. The upper portion of the lens attenuated the light by a factor of 5.5, and the lower slit attenuated the light by a factor of 4.0.

Litton AN/PSN-6 Position Location System. This piece of equipment is a man-portable unit that provides position information to the user in the form of LORAN time differences or universal transverse mercator coordinates in eight digits. It was used in the Yakima experiment to measure the lateral deviation of the navigator from the desired course; it was hoped that this instrument could provide a significant methodological breakthrough for assessment of navigation performance.

Compass. A standard, government-issued lensatic compass with luminous dial was used by all soldiers.

Map. Each soldier was given an 8" x 10.5" map with approximately 4 km^2 represented on a scale of 1:10,000. The map is included as Appendix A. The starting point and the legs to all four checkpoints were indicated on the map by thick yellow lines. The bottom right corner of the map listed both the magnetic azimuths and the required distance to be traveled to each checkpoint.

Pretests

History and Experience Questionnaire. This was a brief, 22-item questionnaire designed to obtain a geographic description of each soldier's childhood neighborhood and a description of both childhood and Army navigation experiences. This questionnaire also provided information necessary to select experimental subjects for further testing to see if self-assessments of sense of direction predicted land navigation performance. The questionnaire is included as Appendix B.

Orientation Questionnaire. This served as a followup to the History and Experience Questionnaire for those selected as experimental candidates. The questionnaire represents a slightly modified version of that used by Kozlowski and Bryant (1977) in their research on sense of direction. This questionnaire was used to see whether soldiers' personal attitudes or habits about their own navigation as pedestrians and drivers could predict good and poor performers in a land navigation task. It is included as Appendix C.

Locations Test. This is part III of the U.S. Army Armor Systems Selection Battery (Booklet Two). It measured the ability of soldiers to select correctly a photograph that was taken from the point of view designated in a master photograph. Good performance in this test was expected to correlate highly with a soldier's navigation abilities.

Armed Forces Qualifications Test (AFQT). These percentiles were obtained from Form 20 of the subjects' 201 files.

Witkin's Embedded Figures Test (EFT)--Form A. This is a perceptual test that measures field dependence-independence. It was hypothesized that those who were more field-independent would be better navigators than those who were more field-dependent, because the former would be better able to use a map. That is, field-independent persons could better identify those features which defined their position and could better relate such features from a map to the corresponding terrain.

Experimental Design

The two major variables of this study were illumination conditions and sense of direction (SOD). Illumination conditions consisted of three groups--Day, LAD, and Night. The Day and Night groups performed the navigation tasks under prevailing daylight and nighttime illumination conditions, respectively. The LAD group performed in the same daylight conditions as the Day group but wore LADs to simulate night conditions.

The second variable, sense of direction, was a measured variable determined by the soldiers' responses to a question that asked them to rate how good they thought their SOD was on a 7-point scale. Those considered to have a good SOD scored between 1 and 3, and those classified as having a poor SOD scored between 3 and 7. The overlap of ratings between groups was due to the substitution of a relatively few soldiers who rated themselves as poor in SOD with alternates who had better SOD self-assessments.

Each subject was required to navigate to four checkpoints. The final experimental design incorporated these checkpoints into the third variable to produce a 2 x 3 x 4 (SOD x illumination x checkpoint) mixed, repeated-measures design for statistical analysis. Figure 5 illustrates this design.

			Checkpoints			
Illumination	SOD	Ss	1	2	3	4
Day	Good	1-5				
	Bad	6-10				
LAD	Good	11-15				
	Bad	16-20				
Night	Good	21-25				
	Bad	26-30				

Figure 5. Design used in land navigation experiments.

Procedure

ARI scientists briefed 100 Fort Lewis soldiers on the nature of the experiment, which was to take place during night exercises at the Yakima Test Firing Center. Soldiers who wore glasses were excused, because sizing constraints prevented their wearing the LADs. The remaining soldiers were informed that they had been chosen for further testing, that their names would be used for administrative and statistical control purposes only, and that full confidentiality of their responses would be maintained.

The History and Experience Questionnaire (the first administered) included a question asking soldiers to rate how good they thought their sense of direction was on a 7-point scale from Good to Bad. Forty-five soldiers with scores near the extremes of the scale were considered for further testing. Of these 45 soldiers, 15 were assigned to a "good" sense of direction group, 15 were assigned to a "poor" sense of direction group, and the remainder served as alternates. All 45 soldiers were given the Locations Test before they were dismissed. Finally, the experimenters obtained AFQT scores from existing test files.

All Fort Lewis pretesting was performed on a group testing basis. The remaining pretesting and experimental data collection took place 1 week later at Yakima Firing Center on an individual basis. Each soldier was tested according to a standard procedure. The testing schedule is in Appendix D, and the instructions read to each soldier appear in Appendix E. The procedure involved introducing the problem to the soldier, administering the EFT test, and initiating the navigation task.

In performing the navigation task, each soldier was accompanied by one or two experimenters. During the night and LAD conditions, the experimenter preset the lensatic compass to the correct azimuth for each checkpoint so that the soldier was merely required to align the luminous compass guides. The experimenters stayed behind the navigator so as not to influence the soldier's direction of travel. At intervals of approximately 2 minutes, the soldier was asked to stop, remember his pace count, and wait as the experimenter recorded the eight-digit coordinates supplied by the AN/PSN-6 Position Location System. When the soldier arrived at where he thought the checkpoint was located, the experimenter recorded the time and measured the distance between the proposed and actual checkpoint locations. The soldier was then brought to the actual checkpoint and directed to continue to the next checkpoint.

RESULTS

Table 1 presents the summary statistics for the 2 x 3 x 4 (SOD x illumination x leg) ANOVA on navigation times. An analysis of the significant illumination main effect revealed that the Day group navigated significantly faster than the LAD group, which navigated significantly faster than the Night group. Table 2 presents the mean leg navigation times, which show the main effect of the three illumination groups.

In addition to the illumination main effect, there was a significant interaction between the illumination conditions and the specific legs that comprised the route. Table 2 shows a significant deviation of the LAD group from the other illumination groups in the first leg of the route. Only in the first leg does the LAD group perform at the same level, if not a little worse, than the Night group. This

Table 1

ANOVA of Navigation Times

Source	df	MS	F	p
Between Ss				
I-(Illumination)	2	323967	4.30	.05
D-(Sense of Direction)	1	182599	2.42	n.s.
ID	2	67860	--	n.s.
S(ID)-(Subjects)	24	75386		
Within Ss				
L-(Leg)	3	236961	25.03	.001
IL	6	24429	2.58	.05
DL	3	7397	--	n.s.
IDL	6	8976	--	n.s.
SL(ID)	72	9468		

Table 2

Mean Leg Navigation Times (in Minutes)

Illumination condition	Leg 1 (510 M)	Leg 2 (560 M)	Leg 3 (530 M)	Leg 4 (730 M)
Day	7.7	8.5	9.0	11.0
LAD	11.3	9.6	9.6	13.4
Night	10.6	12.2	11.0	14.4

probably occurred primarily because of the novelty effect of the LADs; after the novelty had worn off, fidelity of night simulation was probably better represented in the last three legs.

By collapsing the time scores across illumination conditions and focusing on the average leg times alone, one can see that navigation times increased over the longer legs of the route. This is reflected in Table 1 through the statistically significant main effect for leg.

Table 3 displays the mean route navigation times for good and poor sense of direction groups across the illumination conditions. With a total N of 30, there was no significant difference between good and poor self-rated navigators. The consistent trend for good SOD soldiers to do better than poor SOD soldiers, however, may justify further study on the utility of self-assessments of sense of direction for predicting navigation performance.

Table 3

Mean Route Navigation Times (in Minutes)

Sense of direction	Illumination conditions		
	Day	LAD	Night
Good	36.8	39.0	44.8
Poor	35.8	48.7	51.9

Table 4 presents the ANOVA results for checkpoint localization error. Neither illumination nor sense of direction significantly affected this error. Table 5 provides the mean checkpoint errors (summed across legs) for the sense of direction and illumination conditions.

The only variable having a significant effect on checkpoint error was route leg. Table 6 presents the mean checkpoint errors for each leg, across each illumination condition. This table shows that as leg lengths increased, the magnitude of checkpoint error also increased.

Table 4

ANOVA of Checkpoint Localization Error

Source	df	MS	F	p
Between Ss				
I-(Illumination)	2	10388	1.85	n.s.
D-(Sense of direction)	1	98	--	n.s.
ID	3	2186	--	n.s.
S(ID)-(Subjects)	24	5613		
Within Ss				
L-(Leg)	3	10465	4.23	.05
IL	6	1346	--	n.s.
DL	3	3811	1.54	n.s.
IDL	6	2622	1.06	n.s.
SL(ID)	72	2471		

Table 5

Mean Checkpoint Error[a] (in Meters)

Sense of direction	Day	LAD	Night
Good	65	78	111
Poor	76	88	96

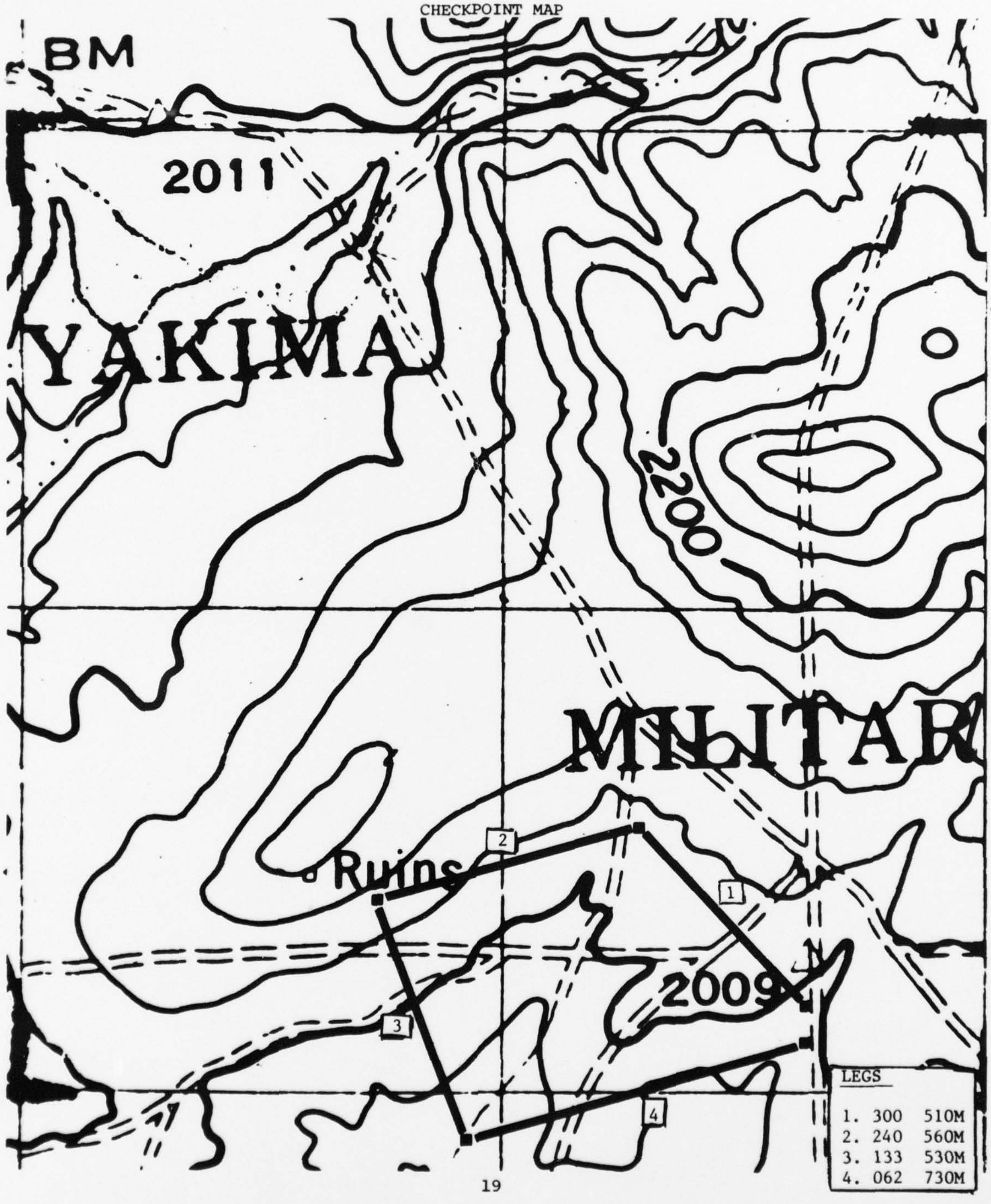
[a]Errors were summed across checkpoints.

Table 6

Mean Checkpoint Error Per Leg (in Meters)

Illumination conditions	Checkpoint 1 (510 m)	Checkpoint 2 (560 m)	Checkpoint 3 (530 m)	Checkpoint 4 (730 m)
Day	51	82	46	104
LAD	55	98	88	92
Night	82	109	102	120

APPENDIX A
CHECKPOINT MAP



APPENDIX B

HISTORY AND EXPERIENCE QUESTIONNAIRE

NAME ________________________________

RANK ______________

NAME OF
IMMEDIATE SUPERVISOR (i.e., who tells you your orders) ____________________

1. Age ____________

2. Height ______________

3. Weight _________

4. Right- or Left-Handed.

Right _____ Left _____

5. Do you wear glasses during combat training?

Yes ____ No ____

6. How long have you been in the Army?

________ Years ________ Months

7. How long have you been at Ft. Lewis?

________ Years ________ Months

8. Have you ever participated in an exercise at the Yakima Firing Center?

Yes ________ No ________

9. Approximately how many classroom courses have you had which covered the topic of navigation? ________________________

10. Approximately how many field exercises involving navigation have you participated in? ________________________________

11. Before entering the Army, did you ever go hiking? (circle the most appropriate item)

very rarely | rarely | sometimes | frequently | very frequently

12. Before entering the Army, have you ever used a compass?

very rarely | rarely | sometimes | frequently | very frequently

13. Were you ever a Cub Scout? _______ Yes _______ No

14. Were you ever a Boy Scout? ______ Yes ______ No

15. Where did you live during most of your childhood (From ages 5 to 12)?

__________ Large City __________ Small City

__________ Suburbs __________ Rural

16. What was the distance between your house and your nearest childhood neighbor's house?

______ Just a few yards (Less than 25 yards)

______ A short walk (25 to 100 yards)

______ A moderate walk (100 to 400 yards)

______ A long walk (400 yards to 1 mile)

______ Within driving distance (Over 1 mile)

17. Which best describes the terrain of your childhood neighborhood?

________ Mountains ________ Hills

________ Flatland ________ Waterfront

18. Which best describes the growth around your childhood neighborhood?

________ Heavily Wooded

________ Moderately Wooded

________ Lightly Wooded

19. As a child, did you ever camp outside ....

(a) ... in your own neighborhood?

very rarely	rarely	sometimes	frequently	very frequently

(b) ... away from your own neighborhood?

very rarely	rarely	sometimes	frequently	very frequently

20. Which would you say you were?

__________ "City Boy" ___________ "Country Boy"

21. Which describes you the best?

_______________ Athletic

_______________ Studious

_______________ Hobbyist

22. How good is your sense of direction?

Good _____ : _____ : _____ : _____ : _____ : _____ : _____ Bad

APPENDIX C

ORIENTATION QUESTIONNAIRE

NAME ____

There are no correct or incorrect answers to these questions. Please answer them in order. Proceed quickly and do not go back to a previous answer.

A note on filling out this questionnaire: Many questions are followed by answers in scale form. To answer, place a check mark in the space that best indicates your response.

Examples: How do you feel about falling down ten flights of stairs?

dislike __C__ : _____ : _____ : __B__ : _____ : _____ : __A__ like

Response "A" : indicates that you like falling down stairs very much.

Response "B" : indicates that you neither like nor dislike falling down stairs.

Response "C" : indicates that you strongly dislike falling down stairs.

---

1. How good is your sense of direction ......

(a) In the city?

GOOD _____ : _____ : _____ : _____ : _____ : _____ : _____ BAD

(b) In the country:

GOOD _____ : _____ : _____ : _____ : _____ : _____ : _____ BAD

2. How good is your ability to judge distance?

GOOD _____ : _____ : _____ : _____ : _____ : _____ : _____ BAD

3. How good is your ability to judge time?

GOOD _____ : _____ : _____ : _____ : _____ : _____ : _____ BAD

4. How good is your memory for the following things:

(a) Places?

GOOD _____ : _____ : _____ : _____ : _____ : _____ : _____ BAD

(b) Faces?

GOOD _____ : _____ : _____ : _____ : _____ : _____ : _____ BAD

(c) Names?

GOOD _____ : _____ : _____ : _____ : _____ : _____ : _____ BAD

5. Pretend that you have a car readily available. If you're in no hurry, how often will you walk rather than drive to a destination for the distances listed below? Circle the correct response.

I will walk:

(a) Short distances (less than one mile)

very rarely	rarely	sometimes	frequently	almost always

(b) Medium distances (1 to 2 miles)

very rarely	rarely	sometimes	frequently	almost always

(c) Longer distances (More than 2 miles)

very rarely	rarely	sometimes	frequently	almost always

6. Do you drive? _____ Yes _____ No

7. a. Assume that you yourself know how to reach a particular destination. Would you enjoy giving directions to that destination to other people?

strongly dislike _____ : _____ : _____ : _____ : _____ : _____ : _____ strongly like

b. Do you think that you are good at giving other people directions?

Very Bad _____ : _____ : _____ : _____ : _____ : _____ : _____ Very Good

8. (a) In general, when driving a car, do you try whenever possible, to find new routes?

very rarely	rarely	sometimes	frequently	almost always

(b) In general, is it important that the new routes you take are more efficient?

not important	somewhat important	moderately important	very important	extremely important

(c) In general, is it important that the new routes you find are interesting?

not important	somewhat important	moderately important	very important	extremely important

9. (a) In general, when walking, do you try, whenever possible, to find new routes?

very rarely | rarely | sometimes | frequently | almost always

(b) In general, is it important that the new routes that you do find are more efficient?

not important | somewhat important | moderately important | very important | extremely important

(c) In general, is it important that the new routes you find are interesting?

not important | somewhat important | moderately important | very important | extremely important

10. Assuming that you are with someone who drives as well as you do, would you rather be the driver or passenger in a car?

______________________ Driver ________________________ Passenger

11. Rate the following adjectives to describe how you feel when you are lost (i.e., when you do not know how to reach an anticipated destination). Assume that you would like to reach your destination soon, but that you have no appointments.

anxious _____ : _____ : _____ : _____ : _____ : _____ : _____ not anxious

attentive _____ : _____ : _____ : _____ : _____ : _____ : _____ inattentive

calm _____ : _____ : _____ : _____ : _____ : _____ : _____ excited

good _____ : _____ : _____ : _____ : _____ : _____ : _____ bad

despairing _____ : _____ : _____ : _____ : _____ : _____ : _____ hopeful

12. How good are you at following written directions to go to a place you have never been before?

very poor | poor | fair | good | excellent

13. How good are you at remembering verbal directions and using them to get to a place you have never been before?

very poor | poor | fair | good | excellent

14. (a) Do you think you daydream more or less than the average person?

much less | less | same | more | much more

(b) Do you ever daydream while driving?

very rarely	rarely	sometimes	frequently	very frequently

(c) Do you ever daydream while walking?

very rarely	rarely	sometimes	frequently	very frequently

15. When you are traveling through an area that you are unfamiliar with, do you make a conscious effort to note new details in the landscape?

very rarely	rarely	sometimes	frequently	almost always

16. When you are traveling through an area that you are unfamiliar with, do you make a conscious effort to remember new details in the landscape?

very rarely	rarely	sometimes	frequently	almost always

17. (a) Have you ever had an experience where you felt that you have done something or been somewhere before, even when you know you haven't?

very rarely	rarely	sometimes	frequently	almost always

(b) With what intensity do you usually have this experience?

very weakly	slightly	moderately	strongly	very strongly

18. When you are a passenger in a car, do you often remember the route you have travelled?

very rarely	rarely	sometimes	frequently	almost always

19. After being a passenger in a trip through a medium sized city, do you think you could redrive the route if the entire trip was:

(a) 5 minutes long _______ Yes _______ No
(b) 15 minutes long _______ Yes _______ No
(c) 30 minutes long _______ Yes _______ No
(d) 1 hour long _______ Yes _______ No
(e) 2 hours long _______ Yes _______ No

20. Do you usually carry a watch with you?

_______ Yes _______ No

21. Do you prefer to be early or exactly on time for an appointment?

________ Early _________ Exactly on time

22. Do you enjoy reading maps?

Hate to _____ : _____ : _____ : _____ : _____ : _____ : _____ Really enjoy it

23. When driving to an unknown destination:

(a) Do you inspect a map before leaving?

very rarely	rarely	sometimes	often	almost always

(b) Do you use a map throughout your route?

very rarely	rarely	sometimes	often	almost always

(c) Do you ask for directions when you think you are near?

very rarely	rarely	sometimes	often	almost always

24. When referring to a map in your car, do you always keep the map right-side-up or do you turn the map in the direction of your travel?

__________ Right-side-up __________ Direction of travel

25. When you were a little kid, do you ever recall becoming lost while you were out on an adventure or exploring with a friend?

________ No, I can not recall this ever happening.

________ I remember it happening a couple of times, or was told it did.

________ I remember it happening many times, or was told it did.

26. Do you find traveling at night easier or more difficult than traveling during the day?

________ Day is easier ________ Night is easier ________ Both are the same

27. On a trip, which would you rather be: the driver; the map reader; or

a passenger. Circle your choice.

APPENDIX D

Schedule of Testing

Date	Time	Illumination Group	SOD Group	Subject No.
31 May 77	1035	DAY	Good	26
"	1340	LAD	Good	28
"	2000	NIGHT	Good	29
1 Jun 77	1410	DAY	Poor	15
"	1630	LAD	Poor	14
"	2300	NIGHT	Poor	13
2 Jun 77	1335	DAY	Good	30
"	1617	LAD	Good	20
"	2213	NIGHT	Poor	1
3 Jun 77	1410	LAD	Good	27
6 Jun 77	1348	LAD	Good	16
"	1555	DAY	Good	17
"	2227	NIGHT	Good	18
7 Jun 77	1400	LAD	Poor	10
"	1700	DAY	Poor	9
"	2200	NIGHT	Poor	8
8 Jun 77	1430	LAD	Good	25
"	1640	DAY	Good	24
"	2200	NIGHT	Good	23
9 Jun 77	1315	LAD	Poor	12
"	1525	DAY	Poor	11
"	2215	NIGHT	Poor	2
10 Jun 77	1330	LAD	Good	21
"	1530	DAY	Good	22
12 Jun 77	2200	NIGHT	Good	19
"	2345	NIGHT	Poor	7
13 Jun 77	0200	NIGHT	Poor	6
14 Jun 77	1030	DAY	Poor	3
"	1230	LAD	Poor	4
"	1400	DAY	Poor	5

APPENDIX E

INSTRUCTIONS TO EACH PARTICIPANT

I'm Dr. _____________ from the Army Research Institute in Alexandria, VA. You've been specially selected from all of the people in your battalion to help us in this study of land navigation. We are trying to find out how to help the Army teach people to navigate more accurately. During the next 2 1/2 hours you will be asked a series of questions, given the opportunity to compete on a challenging land navigation problem and asked to participate in two simple exercises related to your ability to locate both yourself and some figures in relation to the surrounding area.

The first part of our time is devoted to finding out how you feel about the upcoming tests. I am going to give you a list of words and you are to decide whether or not each word describes the way you feel right now about the next 2 hours of testing. Please print your name, date, and time on the front of this paper, and then, carefully read the instructions. When you have done so, let me know. ------------ O.K., here is the list of adjectives which might describe how you feel about the upcoming test. Please go down the list and check those words which describe your present feelings.

The next exercise is designed to tell how well you can pick important features out of a map or out of the real terrain. It's called the Witkin's Embedded Figures Test. Please come with me to where we can sit down and be comfortable because this will take about 30 minutes.

(ADMINISTER EFT)

Now, I'd like you to study this little map. The yellow line indicates the route you are to follow in your navigation exercise. Map study is most effective when you note the relationship of the check points to the surrounding terrain. For example, note that there are four legs in your test route each ending at a checkpoint. Note also that the start point is right near a road and about 200 meters south of an intersection. You will also notice that the compass heading and distance are given for each leg of the route. Do you know how to use a compass? (IF NOT, GIVE BRIEF INSTRUCTION).

Do you know your pace count? (IF S ANSWERS YES OR NO GIVE THEM THE OPPORTUNITY TO PACE ALONG TAPE MEASURE AND VERIFY WHAT HIS COUNT IS!!)

O.K., now let me tell you what the basic procedure will be. When we're ready to go, I will lead you to the starting point. There, you will inspect your map, shoot your azimuth and note your distance to be traveled. When you are ready to begin just start and I will follow you. As you walk the course, I will stop you every few minutes in order to take a reading from the LORAN system (EXPLAIN LORAN IF NECESSARY). Since I will be stopping you every so often, it is quite possible that you will lose your attention and forget your pace count. Please note this possibility and try to prevent it from happening.

As you are traveling, you can stop as often as necessary to check your compass. When you think you have reached the checkpoint, let me know.

REMEMBER Even though the start point is obviously marked with a pile of rocks and a stake, the checkpoints may not be so obivous. Therefore, rely mostly on your compass and pace count, and use your map to verify your position. DON'T RELY ON LOOKING FOR MAN-MADE MARKERS.

Do you have any questions?

O.K., please carefully study your map for the next few minutes while I get prepared.

(AFTER 15 S HAVE BEEN RUN)
I want you to look at this (YAKIMA ORIENTATION TEST) and read the instruction carefully because this is what I want you to fill out when we finish the navigation exercise. (EXPLAIN CAREFULLY)

LAD'S GROUP: Because of special abilities which showed up in the tests you took, you have been assigned to the experimental group which gets to wear the night simulation devices. If you'll put on the protective mask now, I'll tell you how it works.

(PUTS ON MASK)

The lenses of the mask are treated with special coatings which reduce the bright sunlight to the level of half moon. In a few minutes, you will be able to see pretty well again. You'll notice that at the bottom of each lens is a slit which appears a little brighter than the rest. This is so you can read your map and compass, and so you can look at the ground just in front of you so that you won't fall into holes or something worse. This slit is not to be used to view straight ahead, but only to look down. Now, I want you to sit down beside the goat for a while so you can adapt to the darkness in peace (15 minutes).

NIGHT GROUP: Because of special abilities which showed up in the tests you took, you have been assigned to the experimental group which gets to work the night navigation problem.

DAY GROUP: Because of special qualities that showed up in the tests you took, you have been assigned to our control group whose job is to set standards for the others to follow.

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1 Denver Federal Ctr, Lakewood, ATTN: BLM
12 Defense Documentation Center
4 Dir Psych, Army Hq, Russell Ofcs, Canberra
1 Scientific Advsr, Mil Bd, Army Hq, Russell Ofcs, Canberra
1 Mil and Air Attache, Austrian Embassy
1 Centre de Recherche Des Facteurs, Humaine de la Defense Nationale, Brussels
2 Canadian Joint Staff Washington
1 C/Air Staff, Royal Canadian AF, ATTN: Pers Std Anal Br
3 Chief, Canadian Def Rsch Staff, ATTN: C/CRDS(W)
4 British Def Staff, British Embassy, Washington
1 Def & Civil Inst of Enviro Medicine, Canada
1 AIR CRESS, Kensington, ATTN: Info Sys Br
1 Militaerpsykologisk Tjeneste, Copenhagen
1 Military Attache, French Embassy, ATTN: Doc Sec
1 Medecin Chef, C.E.R.P.A.–Arsenal, Toulon/Naval France
1 Prin Scientific Off, Appl Hum Engr Rsch Div, Ministry of Defense, New Delhi
1 Pers Rsch Ofc Library, AKA, Israel Defense Forces
1 Ministeris van Defensie, DOOP/KL Afd Sociaal Psychologische Zaken, The Hague, Netherlands